Appendix C

WATER AND SEDIMENT QUALITY CONSIDERATION
RELATED TO THE POTENTIAL
SAVAGE RAPIDS DAM REMOVAL

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Tables

Figures

Figures (continued)

Attachment A

WATER AND SEDIMENT QUALITY CONSIDERATIONS RELATED TO THE POTENTIAL SAVAGE RAPIDS DAM REMOVAL

Background

McLaren/Hart (1998) conducted a sediment assessment on samples collected from the exposed area on the margins of Savage Rapids Reservoir. These sample sites are subjected to wetting and drying. Samples from the deeper parts of the reservoir may be different from those on the margins of the reservoir. Sediments below the deeper waters would be inundated longer (or permanently) and would be expected to be more organic. Historically, sediments that accumulate near the dam during the irrigation season are flushed from the reservoir when the stoplogs are removed after the season ends. Consequently, few of the recent sediments are likely to remain in the reservoir.

The marginal sediments average about 600 parts per million (ppm) total organic carbon (TOC). The marginal sediments would also be expected to be oxidized. Sediments from the deeper parts of the reservoir may be oxidized near the sediment/water interface but would be expected to be chemically reduced within a few inches of that surface. The effect of the reduced sediments on water quality could be different from the effect of the marginal oxidized sediments sampled in the McLaren/Hart (1998) assessment.

The McLaren/Hart (1998) assessment analyzed the total concentration of elements in the sediment samples using methods developed by the Environmental Protection Agency (EPA) to evaluate the biological availability of potential contaminants in solid wastes. These were compared against effect levels from the literature, where available, and background concentrations for western soils when effect levels were not available.

There are 3 years of water quality data collected from 1953 through 1956. These years may not be representative of existing conditions, but they do encompass a period during the historic operation of Savage Rapids Dam, including the period in which federally financed repairs were being undertaken. The data are summarized in table 1. The data indicate that the water in the Rogue River was well within any drinking water standard (maximum contaminant level [MCL] or secondary maximum contaminant level [SMCL]), with the exception of the SMCL for color. It should be noted that MCLs and SMCLs apply to treated water; after coagulation and filtration, the color could meet its SMCL. The distinction between MCLs and SMCLs is that MCLs are related to health concerns, and SMCLs apply to aesthetics (e.g., taste and odor).

McLaren/Hart (1998) analyzed the marginal sediments for volatile and semivolatile organic compounds (VOCs and SVOCs). Neither VOCs and SVOCs were found in measurable concentrations in any of the samples. There is no indication of a source of either type of compound upstream from the reservoir, and none should be expected to be found.

Table 1.—Summary of water quality data for the Rogue River at Grants Pass
between January 1953 and September 1956

	Q, daily (ft^3/s)[1]	Ca, dissolved (mg/L)[2]	Mg, dissolved (mg/L)	Na, dissolved (mg/L)	K, dissolved (mg/L)
Minimum	885	5.6	0.5	3.3	1.0
Median	3,171	8.3	3.0	5.0	1.5
Maximum	27,300	26	5.0	9.1	2.8
No. of observations	127	127	127	127	53

	HCO$_3$ (mg/L)	SO$_4$, total (mg/L)	Cl, dissolved (mg/L)	Spec. cond. (µmho/cm at 25 EC)[3]	TDS ROE (180 EC) (mg/L)
Minimum	34	1.0	1.0	62	53
Median	49	2.1	2.2	90	78
Maximum	98	10	3.8	190	136
SMCL[4]	—	250	250	—	500
No. of observations	127	127	127	127	127

	pH	Fe, total (µg/L)[5]	Color (platinum-cobalt units)	F, dissolved (mg/L)	Total NO$_3$ (mg/L)
Minimum	6.6	< 10	< 1	< 0.1	< 0.1
Median	7.1	70	10	0.2	0.6
Maximum	8.1	290	60	0.6	3.0
MCL[6]/SMCL	6.5-8.5	300	15	2.0	45.0
No. of observations	125	58	55	58	127

[1] Cubic feet per second.
[2] Milligrams per liter.
[3] Micromhos per centimeter at 25 EC.
[4] Secondary maximum contaminant level = 2E drinking water standard.
[5] Micrograms per liter.
[6] Maximum contaminant level (only NO$_3$ is an MCL) = 1E drinking water standard.

McLaren/Hart (1998) analyzed the marginal sediments for a variety of metals and metalloids. Most were present in measurable concentrations, but none was above an uncontaminated background concentration. The inorganic contaminants were analyzed because of concerns over the possible contamination of the sediments from the remains of historic mining activities in the upper Rogue River basin. Brooks and Ramp (1968) summarize historic mining in southwestern Oregon and present a list of the mines in two mining areas in the Rogue River basin along with the predominant mineralization in each (figure 1). The hydrologic basin in which each mining area is located is also

OREGON

Rogue River Basin

Pacific Ocean

GOLD BEACH

California
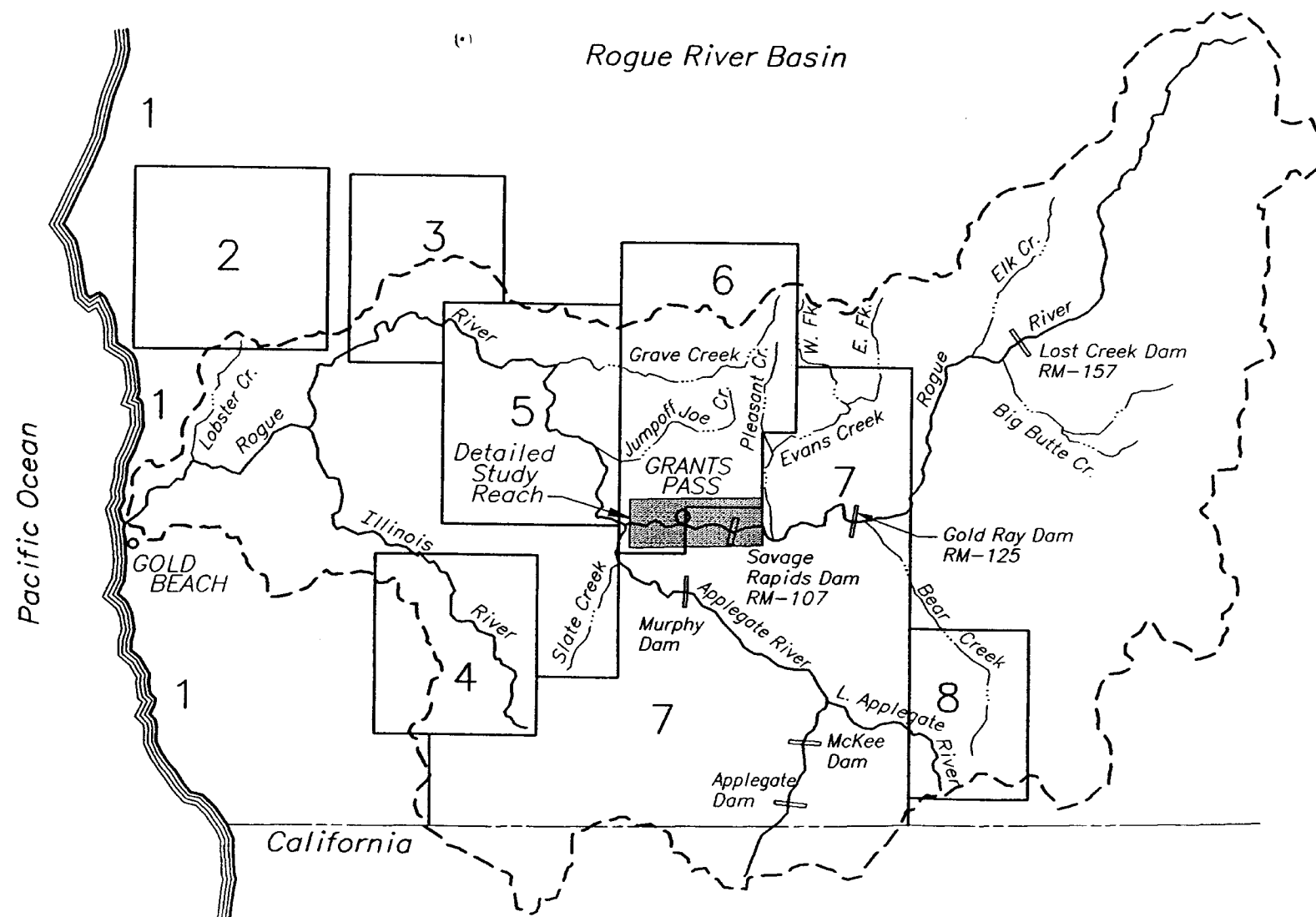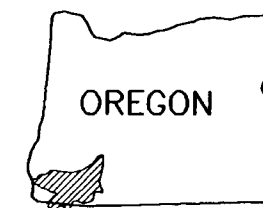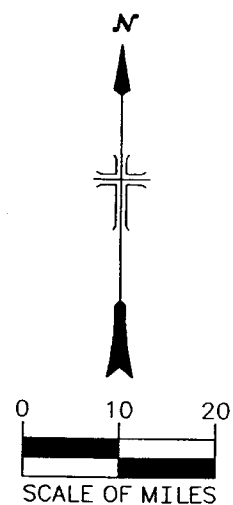
GOLD MINING AREAS OF THE KLAMATH MOUNTAINS

1. Beach placers — Coastal area
2. Salmon Mountains — Six areas
3. Mule Creek — Bolivar area
4. Illinois — Chetco area
5. Galice area
6. Greenback — Tri—county area
7. Gold Hill — Applegate — Waldo area
8. Ashland area

SCALE OF MILES
0   10   20

Lobster Cr.
Rogue
Illinois
River
Slate Creek
Grave Creek
Jumpoff Joe Cr.
Pleasant Cr.
W. Fk.
E. Fk.
Evans Creek
Rogue
Elk Cr.
River
Lost Creek Dam RM—157
Big Butte Cr.
Detailed Study Reach
GRANTS PASS
Savage Rapids Dam RM—107
Gold Ray Dam RM—125
Murphy Dam
Applegate River
L. Applegate River
Bear Creek
McKee Dam
Applegate Dam

Adapted from Brooks and Ramp, 1968.

Figure 1

noted. This information can be used to characterize the potential water quality of runoff and the chemical composition of sediment in that runoff entering the river from the mining areas.

There are two mining areas in southwestern Oregon, both of which are partially within the Rogue River basin. These include the Klamath Mountains and western Cascades mining areas. The Klamath Mountains mining area is divided into 10 subareas. Eight of these subareas are wholly or partially within the Rogue River basin, but only three of them are upstream from Savage Rapids Dam. The three that are upstream from the dam are the Greenback-Tri-County area, which is primarily located in the Evans Creek Basin; the Gold Hill-Applegate-Waldo area, which includes the Applegate River Basin down-stream from the dam, numerous mines east of the town of Rogue River, and the lower end of Bear Creek; and the Ashland area, which is located in the upper Bear Creek Basin, south of Medford. Within the western Cascades area, there are five delineated subareas. There are two mines that are not included within any of the subareas. These two mines are in the headwater areas of the Rogue Basin and will not be considered further.

The Greenback-Tri-County area, as described by Brooks and Ramp (1968), extends from Grants Pass northeastward to include a group of mines which lie in northeastern Josephine County and along the adjacent margins of Douglas and Jackson Counties, where the three counties join. The mining area incorporates parts of the Grants Pass, Greenback, Riddle, and Gold Hill mining districts. The specific mines described by Brooks and Ramp (1968) are in the Grave Creek and Jumpoff Joe Creek Basins, to the west of Grants Pass, but the mineralogy of the area should be similar throughout and would be expected to typify that to the east of Savage Rapids Dam.

The usual ore mineral assemblage of the Greenback-Tri-County area includes native gold, pyrite (iron sulfide = FeS_2), chalcopyrite (copper-iron sulfide = Cu,FeS_2), and arsenopyrite (FeAsS), which is the principal ore material in some of the richer deposits. Occasional galena (lead sulfide = PbS) and sphalerite (zinc sulfide = ZnS) are also noted among the ore minerals. Brooks and Ramp (1968) do note that mineralization in the eastern part of the area contains some copper and significant zinc. If the sediments in Savage Rapids Reservoir have a significant component derived from mine waste, the above metals could be used as indicators.

Ore was concentrated mostly with stamp mills and cyanide. The use of amalgamation plates is also noted. The use of amalgamation plates raises the possibility of mercury releases. In addition, there were several mercury mines in the basin, and production continued to the time of World War II (Brooks, 1963). The primary mercury ore in the basin was cinnabar (HgS), with minute globules of native quicksilver locally occurring with it (Brooks, 1963). Bowen (1969) showed measurable mercury in the sediments of tributaries to the Rogue River.

The Gold Hill-Applegate-Waldo area is a broad region covering 900 square miles in western Jackson and southeastern Josephine Counties (Brooks and Ramp, 1968). Ore minerals include gold, pyrite, chalcopyrite, some galena, pyrrhotite (an iron sulfide = Fe_7S_8-FeS), and occasional sphalerite (Brooks and Ramp, 1968.). Rich, near-surface pocket deposits were also noted; these were associated with sooty iron and manganese oxides. The Sylvanite Mine, near Gold Hill, located a deposit of scheelite (calcium tungstate = $CaWO_4$) associated with the gold ore. Because of this, tungsten may also be an indicator of mine runoff.

Most of the mines, other than placer mines, ceased working by 1940. This would mean that any materials discharged during active mining would be relatively deep in the reservoir sediment or not present at all. There were numerous placer dredging operations upstream from Savage Rapids Dam. The placer operations were located in the main stem of the river and on the lower reaches of many of its larger tributaries. These operated through the 1940s, although several continued into the 1950s and 1960s. Dredging causes sedimentation in the river. However, the sediment had already been in the river and was only relocated. The river gravels that are stirred up during placer mining should be considered either nontoxic or of very low toxicity. Any toxics that could be leached in toxic concentrations should be long gone by the time the particles are trapped in the reservoir.

There were also several large hydraulic operations in the basin (Brooks and Ramp, 1968). Hydraulic mining would contribute more sediment than placer operations, but the sediment quality would be about the same as the placers.

Rationale for Sampling

On the basis of the above, either very low concentrations or no measurable organic contaminants would be expected to be found in the sediments. Heavy metals could be expected to be found in the sediments. Metals from active mining would be buried deeper in the sediments than recent mine drainage. The most common method of mining during the later stages of mining in the basin was hydraulic mining of placer deposits. These deposits would contribute metals that would show up in a total analysis but should be very low in an extract. Because of this potential difference with depth in the sediments, subsamples of selected core samples have been analyzed. The subsamples have been from near the surface of the sediments and near the deepest part of the core column. At a minimum, the analyzed metals in any samples will include copper, iron, lead, manganese, mercury, and zinc. The metalloid, arsenic, has also been included in the minimum list of analytes since arsenopyrite seems to be a relatively common ore in the basin. Cadmium, along with mercury and lead, is one of the "big three" heavy metal poisons (Manahan, 1989). Cadmium occurs as a constituent in lead and zinc ores (Manahan, 1989) (i.e., galena and sphalerite, respectively). Because of its potential toxicity and the occurrence of these lead and zinc minerals in the upper basin, cadmium has also been included in the minimum list of analytes.

McLaren/Hart (1998) analyzed the sediments for a wide variety of inorganic elements and characteristics and for a broad suite of organic contaminants. Since the main goal of the followup sampling was to look for evidence of mining contamination, the analysis only included elements associated with hard-rock mining. No analyses for organic contaminants were performed on the samples. Aside from this, the samples were handled and analyzed in the same manner as in the McLaren/Hart (1998) assessment.

Methods

An overview of the sample sites for contaminant analysis is presented in table 2. The samples were taken from two of the drill holes used in the volumetric study. There were surface samples from each of the holes. The deeper samples were taken from an individual hole. This was felt to be a depositional area within the reservoir at the time it was impounded. The rationale for selecting the sites is presented in the attached field report on the sampling (Attachment A).

Table 2.—Description of sample locations

Drill hole	Depth of water over sediments	Interval depths (feet)		Feet below sediment surface	Hole location
		Surface	Bottom		
AP-99-11	17.5	17.7	19.7	0.2	Across from boat ramp at Savage Rapids Park
AP-99-12	26.1	26.9	28.9	0.8	Between the park and the
		35.7	37.7	9.6	large gravel bar on the north
		41.1	43.1	15.0	side of the reservoir

All analyses were performed using EPA methods (EPA, 1986). The sediments were digested using Method 3051, the microwave modification of Method 3050. The digests were analyzed for the metals, cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), and zinc (Zn), by Inductively Coupled Plasma emission spectroscopy (ICP/ES)-Method 6010. Mercury (Hg) was analyzed by Method 7471 (cold vapor atomic fluorescence). Arsenic was initially analyzed by ICP/ES, but because of the high detection limit (14 milligrams per kilogram [mg/kg] = ppm dry weight), it was rerun by graphite furnace atomic absorption (Method 7060A). There was low spike recovery in the initial determination, so arsenic was determined by the method of standard additions (Method 7000 [sec. 8.7]). Total organic carbon was determined with a carbon analyzer (Method 9060).

There were some difficulties encountered during sample collection (detailed in Attachment A). One of the sample bottles was broken in transit. The broken bottle contained the surface sample for drill hole AP99-12. The results for that sample will be used with some caution because of a potential for contamination. Because the sample was contained in a newly purchased cooler, and the chances for significant contamination were considered low, the sample was analyzed like the others.

Contaminants in Deep Sediments

The results of the chemical analysis of the samples are shown in table 3. There was no detectable cadmium in any of the samples, and measurable mercury was present in only one sample. The measurable mercury occurred in the sample from the broken bottle; the mercury may be the result of slight contamination. The remaining elements, with the exception of manganese, are not much different from the other samples from the same drill hole that were not broken. The manganese is somewhat higher than the other samples from the same drill hole but not greatly higher than the surface sample from the other drill hole. The more upstream surface sample had somewhat higher copper, lead, and zinc than any of the layers of the downstream sample. One oddity in the data in table 3 concerns the layers from AP-99-12. The minimum concentrations of arsenic, iron, manganese, lead, and zinc occur in the middle layer. If there were some long-term trend, the minimum would be expected to be at the top or the bottom. On the other hand, the maximum manganese and mercury are in the surface layer, while the maximum arsenic, copper, iron, and zinc are in the lowest layer. These latter results would be consistent with historic mining as the source of the maxima. The most significant source for those elements with the maximum concentration near the surface would reflect the effects of more recent development in the drainage basin.

Table 3.—Savage Rapids Dam deep sediment samples – total metals (mg/kg) during October 1999

	AP-99-11	AP-99-12				
Element	17.7-19.7'	26.9-28.9'	35.7-37.7'	41.1-43.1'	McLaren/Hart maximum	1999 detection limit
Arsenic	2.19	2.52	2.09	2.61	6.1	0.20
Cadmium	ND[1]	ND	ND	ND	1.5	0.80
Copper	106	35.8	40.2	54.3	956	0.80
Iron	11,200	10,300	8,340	13,200	—	0.80
Lead	18.7	9.3	8.6	13.8	16.0	6.00
Manganese	231	296	119	194	—	0.80
Mercury	ND	0.022	ND	ND	0.114	0.011
Zinc	38.5	25.9	22.7	32.9	46.2	0.80

[1] Not detected at listed detection limit.

The Bureau of Reclamation's (Reclamation) Plan of Study indicated that the results would be compared to those of McLaren/Hart's previous sediment analysis. The minimum concentrations for most elements in both sets of chemical data are the detection limits. Because the detection limits were different between the two data sets, only the maximum concentrations are compared. This is accomplished in table 3 using only the McLaren/Hart maximum concentrations for the elements analyzed in the 1999 deep sediment samples. As can be seen in table 3, the Reclamation samples are within the range of the McLaren/Hart data, with one exception, the lead concentration in the sample from the upstream drill hole (AP-99-11). The maximum lead concentration in the McLaren/Hart data set was 16 mg/kg, while the maximum in the Reclamation deep-water sediment samples was 18.7 mg/kg.

Table 4 shows the results of various other analyses that were run on the Savage Rapids deep sediment samples. The pH of the sediments was essentially neutral. There was little moisture in some of the sediments, but two of the samples were near the usual value of 25 percent. The organic matter content was low, and the TOC was within the range of the McLaren/Hart data. One interesting result is that the sample with the highest percent organic matter did not have any measurable TOC. This seemed contradictory, and a followup investigation of the samples was undertaken. The result appears to be a reflection of the analytical procedure and the particle sizes of the organic matter. The organic matter samples consisted of 10-20 grams of sediment, while the TOC samples consisted of only 0.2 gram of sample. The organic matter was mostly small, woody particles that were nevertheless too large for the TOC samples. This is consistent with the McLaren/Hart (1998) results, where woody particles were reported in some of the cores. Consequently, if none of the particles happened to be included in the TOC sample, the result was an undetectable concentration of TOC. The minimum TOC in the McLaren/Hart samples was also < 0.001 percent.

Table 4.—Miscellaneous measurements in Savage Rapids sediments

Drill hole number and depth interval	pH	Percent moisture	Percent organic matter	TOC (%)
AP-99-11: 17.7-19.7'	6.7	3.0	1.1	< 0.001
AP-99-12: 26.9-28.9'	7.4	29.3	0.8	0.089
AP-99-12: 35.7-37.7'	7.4	24.5	0.7	0.272
AP-99-12: 41.1-43.1'	7.3	10.7	0.8	< 0.001
McLaren/Hart maximum				0.375

As was done by McLaren/Hart, the analytical results are to be compared to various sediment quality criteria. McLaren/Hart compared their results to the ER-L (effects range low), ER-M (effects range median), TEL (threshold effects level), and PEL (probable effects level) concentrations developed by Long et al. (1995) and MacDonald et al. (1996), respectively. The McLaren/Hart results were also compared to LAET (lowest adverse effects threshold),

developed for the Puget Sound cleanup; these are numerically the same as the Dredged Material Evaluation Framework (Corps of Engineers [Corp] et al., 1998) screening level guidelines, which will be used here.
These effects and screening levels are summarized in table 5.

Table 5.—ER-L and ER-M guideline values for trace metals (ppm, dry weight) and percent incidence of biological effects in concentration ranges defined by the two values

Chemical	ER-L[1]	ER-M[2]	TEL[3]	PEL[4]	Screening level[5]
Arsenic	8.2	70	7.24	41.6	57
Cadmium	1.2	9.6	0.68	4.21	5.1
Copper	34	270	18.7	108	390
Lead	46.7	218	30.2	112	450
Mercury	0.15	0.71	0.13	0.7	0.41
Zinc	150	410	124	271	410

[1] ER-L, effects range low (Long et al., 1995).
[2] ER-M, effects range median (Long et al., 1995).
[3] TEL, threshold effect level (MacDonald et al., 1996).
[4] PEL, probable effects level (MacDonald et al., 1996).
[5] Corps et al. (1998) screening level; also LAET, lowest apparent effects threshold used in McLaren/Hart (1998).

Copper was the only element in the deep sediment samples that exceeded any of the guideline levels shown in table 5. All the copper results exceeded the ER-L and the TEL concentrations shown (compare tables 3 and 5). Concentrations of the other elements were well below their respective guideline criteria shown in table 5, although the maximum copper concentration (106 ppm [table 3]) approached its PEL (table 5). None of the samples from the deeper sediments had concentrations of any of the elements that approached the Dredged Material Evaluation Framework screening levels (compare tables 3 and 5). Based on this, these results for the deep sediment samples are within the Tier IIB screening level guidelines.

The McLaren/Hart (1998) results also showed samples that exceeded some of the more conservative guidelines, in particular the TEL concentrations. Of the 50 samples collected by McLaren/Hart (1998), 10 each exceeded the TELs for cadmium and copper, 15 exceeded the TEL for nickel, and 1 exceeded the TEL for chromium. As the effects thresholds become less conservative, the number of samples that exceed the guidelines decreases. There are two cadmium, three copper, and seven nickel samples that exceed their respective ER-L concentrations. One sample each exceeded the PEL for copper and nickel, while only the maximum copper result (956 ppm) exceeded the ER–M and LAET.

This same copper result also exceeds the DMEF screening level. The second highest copper concentration in the McLaren/Hart (1998) data set was 104 ppm, which is very near the maximum from the deeper sediment samples. From a statistical perspective, the maximum copper concentration in the McLaren/Hart (1998) data set appears to be an outlier.

A second purpose behind the additional sampling effort was to evaluate the potential for mining contamination in the sediments. Mining can contribute to sediment contamination either through erosion of solids from spoil piles or by the release of mine drainage that contributes metals precipitated from solution. Mine-contaminated sediments would be enriched in iron relative to normal background concentrations. Pais and Jones (1997) give a normal background concentration for soils, the principal source of sediments, as 38,000 ppm and a normal background for the lithosphere as 41,000 ppm. The iron concentrations in the Savage Rapids deeper sediments ranged from 8,340 to 13,200 ppm. These concentrations are well below the background concentrations noted above. Iron in stream sediment downstream from sources
of mine-drainage contamination are more likely to be very high; for example, concentrations of iron in the Upper Arkansas River basin of Colorado range from 4 (approximate background) to 29 percent (Church et al., 1994) (i.e., 40,000 to 290,000 ppm). The iron concentrations from Savage Rapids Reservoir are around ¼ background.

In the case of the Arkansas River, lead and zinc turned out to be the better indicators of mine-waste associated contamination. Lead and zinc concentrations in the sediments were over 500 and 1,500 ppm, respectively, in the vicinity of contamination. The concentrations decreased steadily downstream to concentrations of 37 and 180 ppm
in reservoir sediments 150 miles downstream (Church et al., 1994.). These latter concentrations are still much greater than those observed in Savage Rapids Reservoir, where the maximum lead was 18.7 ppm, and the maximum zinc was 38.5 ppm. Background lead in the lithosphere is given as 14 ppm by Pais and Jones (1997); this value is bracketed by the lead data from the deeper sediments from Savage Rapids
(i.e., 8.6 to 18.7 ppm). On the other hand, the background concentration for zinc is given as 80 ppm (Pais and Jones, 1997), which is more than twice as large as any of the results from sediments from Savage Rapids.

In summary, samples collected from the deeper sediments in Savage Rapids Reservoir in 1999 showed analytical results that were within the range of samples collected
from the edges of the reservoir in 1998. With the exception of the maximum copper concentration in samples collected during 1998, all results are below the Dredged Material Evaluation Framework (Corps et al., 1998) screening levels and seem to meet the criteria for open water disposal. Based on a comparison of sediments contaminated by mine drainage and a set representative of background concentrations of the elements that were sampled, the Savage Rapids sediments are much like the background in some cases and much below an average for the background in others. Based on this result, it has been concluded that the sediments are not contaminated with mine wastes.

McLaren/Hart (1998) analyzed the Savage Rapids samples for 21 organochlorine pesticides and 64 SVOCs. Of the list of analytes, benzoic acid was detected in one sample out of a total of five; the concentration in the sample did not exceed the available benchmark (an LAET of 650 micrograms per kilogram). Because there were no detections in 50 samples for 85 other organic analytes, the single value was considered a statistical outlier (McLaren/Hart, 1998.). The LAET benchmarks are essentially the same as the Corps et al. (1998) screening levels. (There are a few of the organic compounds that have an LAET benchmark that have no SL.) The comparison made to the set of LAET benchmarks is equivalent to a comparison to SLs. Since any organic contaminants were considered just as likely to occur in more recent sediment as in older sediment, Reclamation felt the McLaren/Hart (1998) study was adequate, and none of the deep sediment samples was analyzed for organics.

Water Quality

There are two aspects to potential water quality effects related to the removal of the dam. One is related to the potential leaching of contaminants from the sediments; the other is related to the sediments themselves. Based on the sediment chemistry presented earlier, the release of contaminants from the sediments will probably not significantly affect water quality in the river downstream from the dam.

There is a relationship between water quality and flow in most rivers of the western United States. In terms of total dissolved solids (TDS), this takes the form of an inverse relationship. This is because higher flows increasingly dilute saline base flows. However, this is not true of the Rogue River. Scattergrams of TDS plotted against flow for the period January 1953 through September 1956 are shown in figure 2. The upper plot (figure 2A) shows all the TDS data. The best fit line (regression line) was based on a log transformation of the flow data and untransformed TDS data. In most cases in the western United States, the regression would be based on a log transformation of both variables. The best fit regression line in figure 2A (i.e., the line designated pred.) is a constant 77 milligrams per liter (mg/L) TDS across the range of flow from 885 to over 15,000 cubic feet per second [ft³/s]). The regression is not statistically significant. The TDS data in figure 2A include one outlier.

The point well above the others on the plot is a TDS of 136 mg/L, which is well above the next highest value. The usual procedure in statistics is to delete outliers and redo the procedure. This is done in figure 2B. With the outlier deleted, the best fit line shows a slight downward slope; however, the decrease is only from a maximum of 78 mg/L to a minimum of 75 mg/L. Once again, the regression is not statistically significant.

The use of iron as an indicator of possible mining pollution was mentioned earlier. At the time the TDS data were collected, iron data were also collected but only in 1953 and
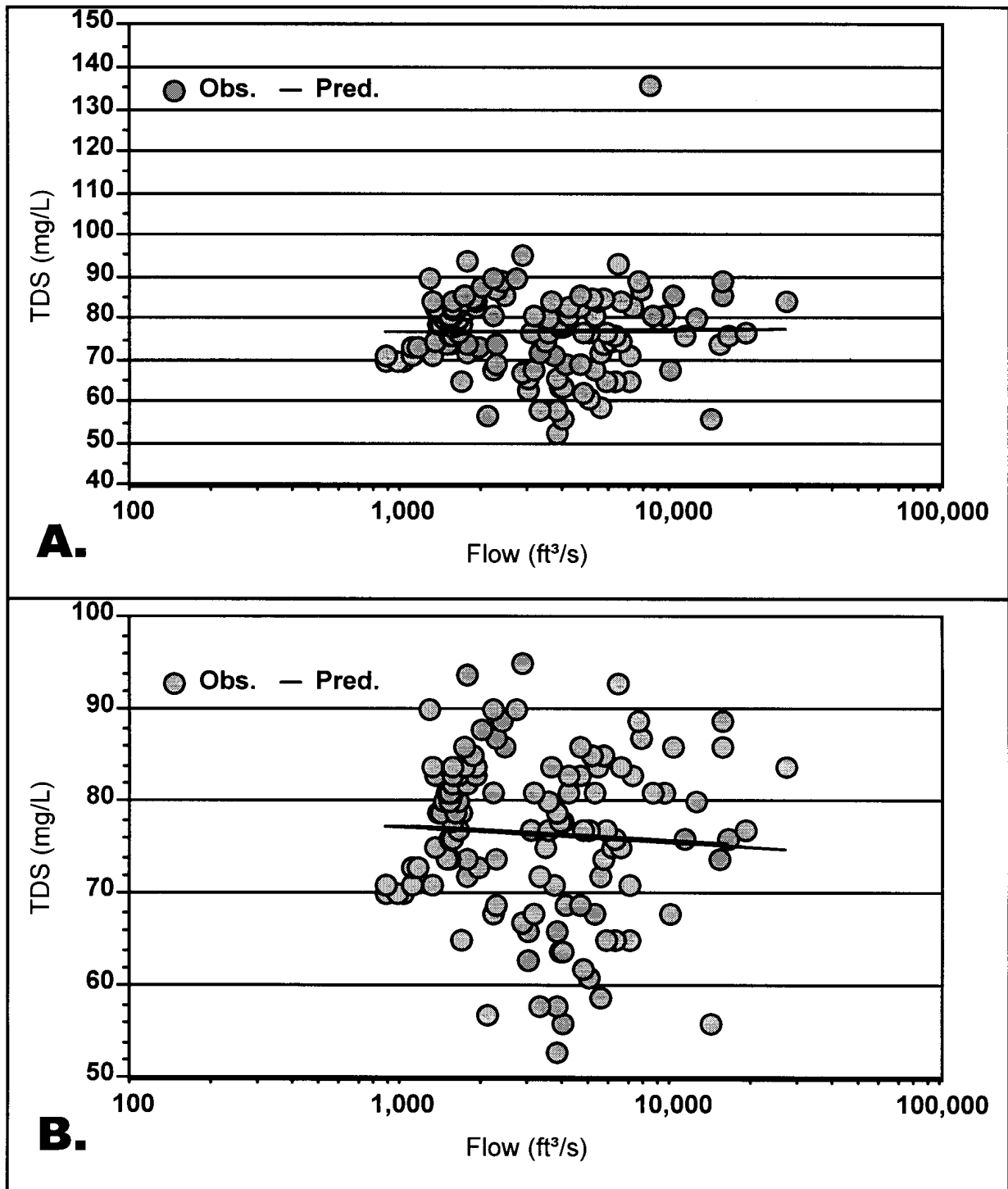
Figure 2.—TDS-flow relationships for the Rogue River at Grants Pass (1953-56).

1954. The iron data, along with the flow data, are plotted as a time series in figure 3A. There is also a grid line on the iron axis that a shows a drinking water SMCL of 300 micrograms per liter (µg/L). The SMCL applies to treated water and is not exceeded by any of the iron samples. The maximum total iron in the 2 years of samples was 290 µg/L. This indicates that iron, at the time, was relatively low.

Figure 3B shows a scattergram of total iron data plotted against flow. Both are on logarithmic axes. The "best fit" line is also plotted on the scattergram. The relationship, unlike the one for TDS, is statistically significant; it is also positive (i.e., as flow increases, total iron increases). This indicates that most of the iron is in suspended form and that the source is erosive. This does not mean that mining is not the source, but it indicates that if it is the source, iron is being eroded off the sites. Given the low maximum concentration of iron, the source cannot be particularly significant.

The City of Grants Pass Water Treatment Plant has monitored certain aspects of the water quality of the Rogue River since the 1930s. Data from 1940 to the present are available in electronic format. Those data were provided to Reclamation. The monitoring data are summarized in table 6. Instead of flow, the monitoring data files included a water level measurement. The flow data substituted in table 6 were downloaded from the U.S. Geological Survey National Water Information System (NWIS) web site. The flow data encompass the period January 1, 1940, through September 1998. The city's water quality data encompass the period from January 1, 1940, through April 30, 1999. The initial date in the NWIS data file was set to 1940 to be comparable to the water quality data.

The turbidity data are of most interest to this study. However, turbidity measurement technology has changed since the monitoring period began. Prior to the routine use of the Nephelometric method, the standard method for measuring turbidity was the Jackson candle turbidimeter (Brown et al., 1970). The lowest turbidity that could be measured directly was 25 Jackson Turbidity Units (JTU) (Brown et al., 1970). The Nephelometric method measures turbidity in Nephelometric Turbidity Units (NTU), which are equal to the JTU at a turbidity of 40; however, differences may occur across a range of turbidity owing to fundamental differences in optical systems. This may account for the large differences between the earlier data and the more recent data (table 6, figure 4). Alternatively, there is also a strong relationship between turbidity and flow (figure 5), i.e., $r = 0.593$, $n = 21,340$. A plot of the flow data similar to the one for turbidity in figure 6 shows that flow has also varied over the 60-year monitoring period. Based on a comparison of the turbidity and flow data in figures 4 and 6, respectively, the differences in turbidity during the monitoring period appear to be due to a combination of the effects of the change in technology and the influence of a difference in hydrologic conditions over the period.

The data presented earlier for TDS and iron were collected in the 1950s. Figure 6 indicates that the 1950s were much above the other decades in terms of flow. A
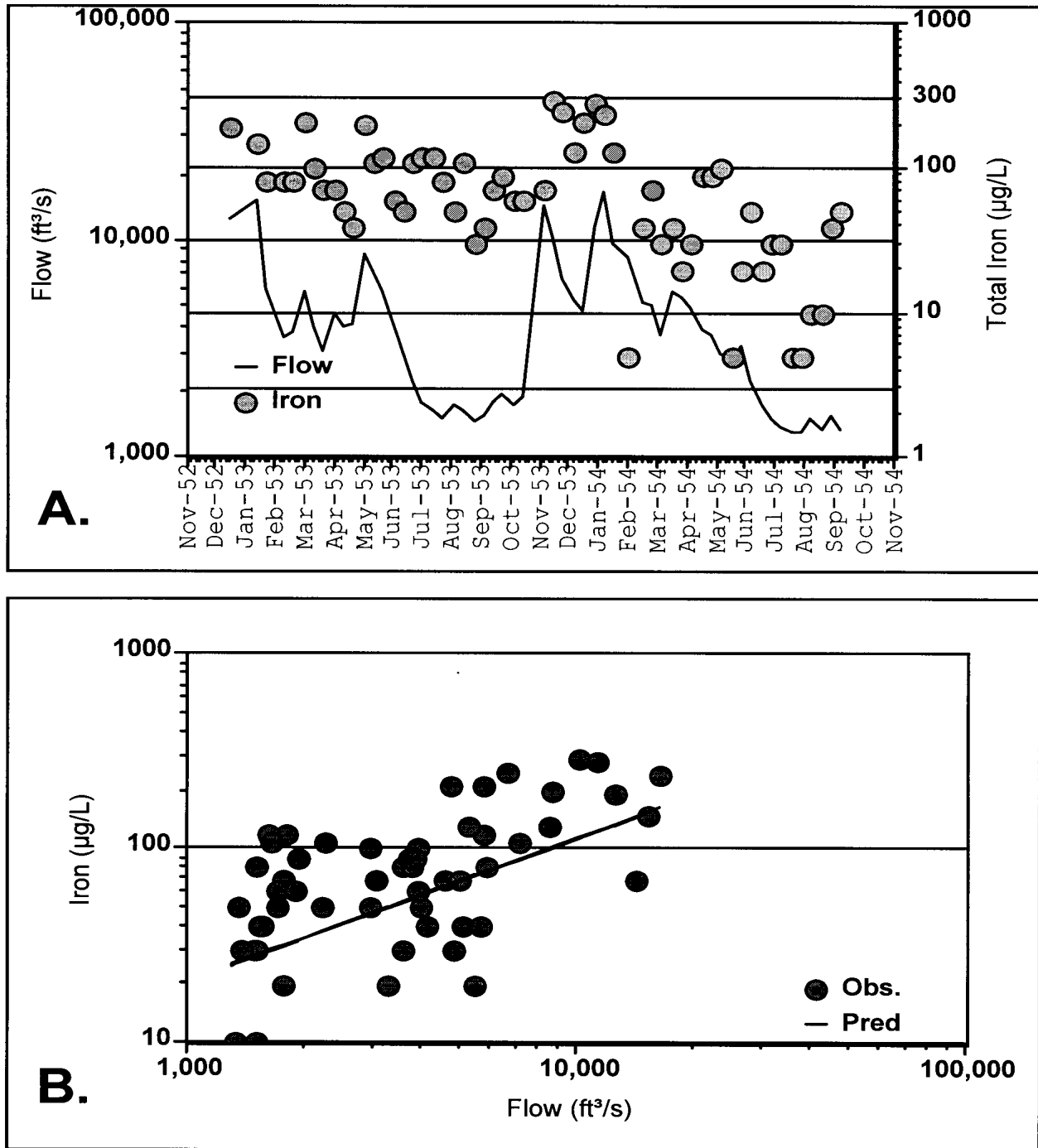
Figure 3.—(A) Time series of flow and total iron in the Rogue River at Grants Pass;
(B) Scattergram of iron on flow in the Rogue River at Grants Pass in 1953-54.

Table 6.—Summary of water quality and flow data for the Rogue River at Grants Pass

		Flow (ft³/s)	Temperature (° Fahrenheit)	Precip. (inches)	Turbidity (JTU)	pH
All data	Minimum	606	32	0	< 1	5.3
	Median	2,310	51	0	11	7.3
	Maximum	124,000	78	19	4250	9.1
	No. of cases	21,458	21,505	18,017	21,478	21,319
1940s	Minimum	637	29.2		3	6.8
	Median	2,080	50		20	7.4
	Maximum	53,700	74		1,100	8.6
	No. of cases	3,653	3,635	0	3,645	3,639
1950s	Minimum	862	32	0	7	6.4
	Median	2,795	50	0	25	7.4
	Maximum	107,000	74	5.27	2,200	8.4
	No. of cases	3,652	3,636	3,652	3,624	3,627
1960s	Minimum	606	32	0	2	5.3
	Median	2,280	50	0	20	7.4
	Maximum	124,000	78	10.2	4,250	9.1
	No. of cases	3,653	3,653	3,653	3,652	3,645
1970s	Minimum	710	32	0	1	6.1
	Median	2,330	51	0	6	7.3
	Maximum	85,800	74	3.35	380	7.7
	No. of cases	3,652	3,651	3,652	3,649	3,565
1980s	Minimum	906	32	0	< 1	6.0
	Median	2,330	52	0	3	7.2
	Maximum	50,400	70	19	200	8.3
	No. of cases	3,653	3,597	3,653	3,577	3,518
1990s	Minimum	744	32	0	< 1	6.7
	Median	2,250	52	0	2	7.4
	Maximum	69,000	74	9	1,093	8.2
	No. of cases	3,195	3,333	3,407	3,331	3,325

A statistical comparison (Fisher's Least Significant Difference Test) indicates that the flows during the 1950s were significantly higher than in any of the other decades shown. Since there was no TDS-flow relationship under those conditions, there should be none under any conditions within the larger flow range available. Alternatively, because of the relationship between iron and flow in the 1950s, concentrations of iron that are much higher than the concentration for the 1950s are not likely. The fact that iron should be no higher than con-centrations of iron in the 1950s would also indicate that if there was no great effect due to mine wastes based on the 1950s data, there would probably be none under conditions that would be encountered over a broader period of time.
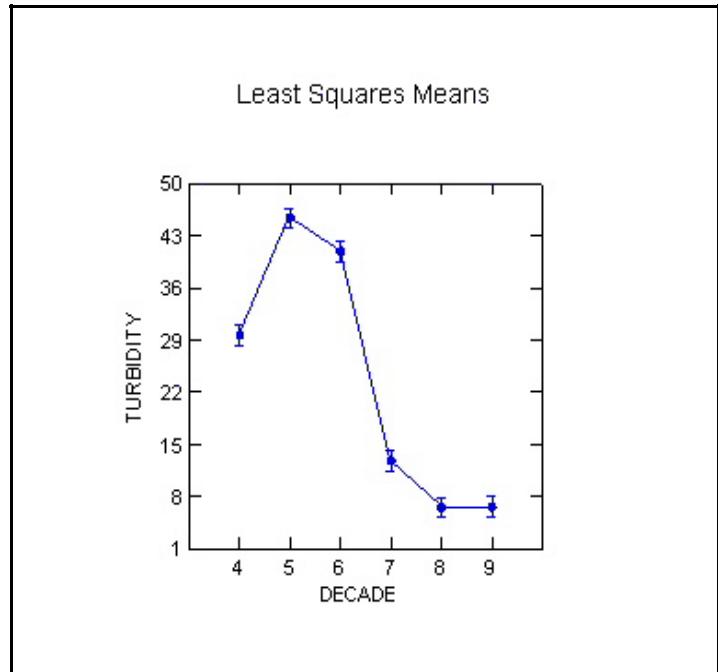

Figure 4.—Mean turbidity and confidence interval in each decade from 1940 through 1999.
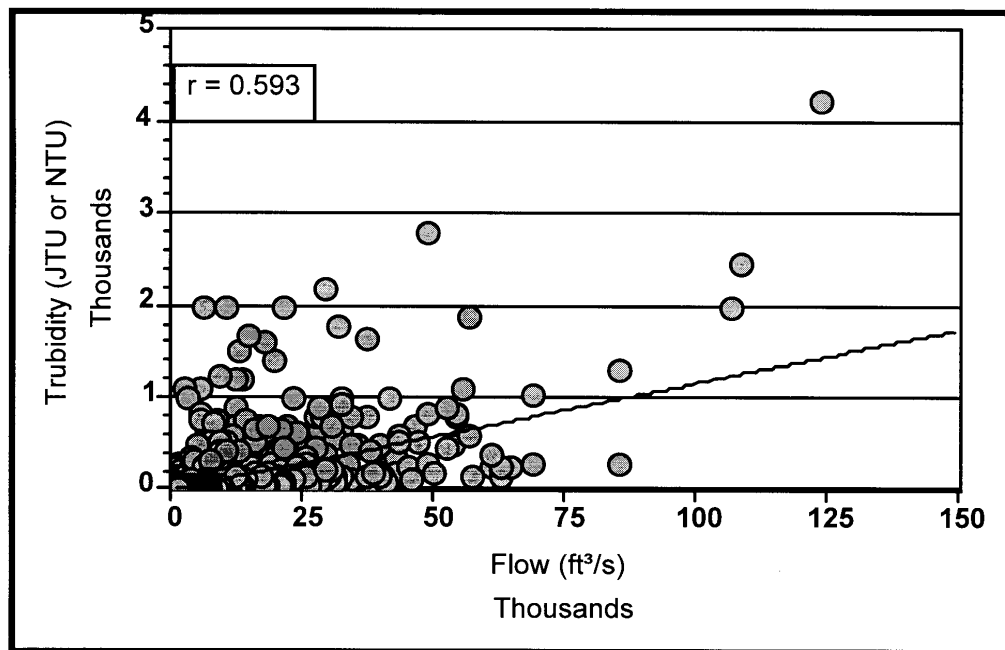

Figure 5.—Relationship between turbidity and flow in the Rogue River at Grants Pass.
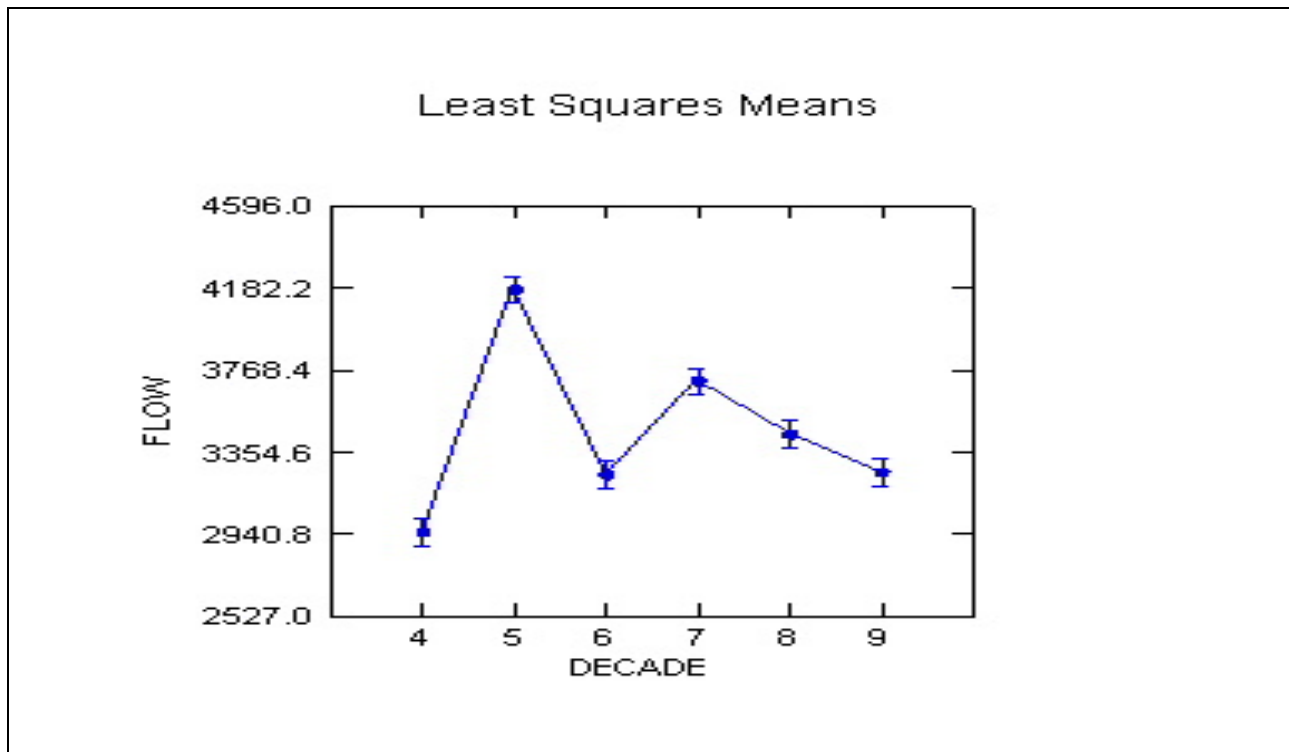
Figure 6.—Mean flow and confidence interval for each decade from 1940 through 1998.

Turbidity is only indirectly related to suspended solids, although it is, by definition, the reduction in light due to the presence of such particles. Suspended solids may consist of clay or silt, finely divided organic matter, plankton, or other suspended microscopic organisms. Attempts to correlate turbidity with the weight concentration of suspended matter are impractical because the size, shape, and refractive index of the particulate matter are important optically but bear little relationship to the concentration or specific gravity of the suspended matter. Nevertheless, turbidity is important in water treat-ment. The drinking water standard for turbidity is 1 NTU. Also, turbidity can be measured rapidly and easily. As can be seen from table 6, the turbidity of the raw water has been very high in the past (> 4,000 JTU), although the more recent data do not approach that maximum from the 1960s. The assessment from Appendix B based on the sediment data indicates that suspended solids would increase for at least the first year if the dam is removed, and the increase may extend as long as 10 years.

The suspended solids available for erosion would consist primarily of coarser particles. The fines that would have the greatest effect on turbidity constitute less than 2 percent of the sediment in the reservoir. The effect on turbidity will reflect the rate of the erosion of the fines. If initial erosion of sediment consists mostly of finer particles, the effect would be to increase the turbidity for a short period of time. If the erosion of fines is slow and regular, then the increase in turbidity would be comparatively small but

would extend for the duration of the erosion period. As has been noted above, the rate of erosion would depend greatly on the sequence of flows following the removal of the dam.

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Attachment A

From: Richard Link
To: Fahy, Juli; Yahnke, James
Date: Thu, Oct 7, 1999 9:02 AM
Subject: Savage Rapids - Heavy Metals Samples

Dear Jim and Juli,

I sent five samples to Juli yesterday for the heavy metals testing portion of the Savage Rapids sedimentation study. They are going via Federal Express and you should receive the cooler today. I thought I would write up a brief summary of field testing procedures and site conditions so that we are all on the same page.

Before we left for the field, Jim and I discussed our goals and decided to try to obtain two samples from about two holes (i.e., four total samples). One sample would be collected from the surface of the lakebed and then a second sample would be collected from the base of the reservoir sediments just above the pre-dam riverbed. In practice, collection of the first sample at the top of the reservoir sediments/lakebed proved to be very difficult in the extreme due to the generally low density of the material and we had no recovery of this sample in 10 of 12 holes. I have shipped the two samples we did recover, but the one from AP-99-11 is very coarse grained with high concentrations of gravel. This hole is the most upstream of the 12 and is located across from the boat launch at Savage Rapids Park. The other 3 samples come from AP-99-12 which is located between the park and the large gravel bar on the north side of the reservoir. This area appears to be a pre-dam topographic low in an old pool area and the holes drilled in this pool terminated at depths ranging from 10 to 12 feet lower than the base elevation of the dam. If heavy metals are present at Savage Rapids, I would think they would be concentrated in this upstream pool area, so the samples from AP-99-12 are probably the most important.

We were set up to sample with a 2.75-inch I.D. split-tube, stainless steel barrel. Previous sampling in the other holes had shown us that we could not retrieve samples without the use of a basket catcher and plastic Saran wrap placed behind the catcher to act as a baffle. Use of flapper valves had been totally ineffective. We had a teflon-coated basket for use with the stainless barrel, but initial testing with the barrel had no recovery and it was evident that the fingers of the basket were too widely spaced to retain the sample inside the barrel. I called Jim and reported this problem. We did have a larger, non-stainless barrel on hand which we were using to obtain samples for standard properties testing that had a much better basket system with numerous, closely spaced fingers. We were getting good recovery with that barrel, although we were getting the best results when spraying the inside of the barrel with PAM (a cooking agent used to keep food from sticking to frying pans, etc.). **Jim and I decided to proceed with the non-stainless barrel in order to get the samples.** Jim

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requested that I thoroughly decontaminate the non-stainless barrel and then retain a sample of the wash water to establish any background contaminant levels.

I completed the decontamination of the barrel using a gallon of de-ionized water obtained from our USBR water quality lab in Boise mixed with about 1.25 fluid ounces of Liqui-Nox detergent. The barrel was then rinsed in a spray of de-ionized water. A sample of this wash water is included in the cooler for testing. This decontamination procedure was used for all the samples submitted for testing, except one which is described below. Initial attempts with the sampler in AP-99-9 and -10 continued to have no recovery despite use of the finer fingers and the Saran wrap. In the last two holes, I decided to resort to spraying the interior of the barrel with PAM and had good recovery in all four sample intervals. **You should be aware that there is potential for PAM to be present in these samples**, but I do not think there should be any impact to the heavy metals as PAM is a house-hold cooking ingredient.

Drill hole AP-99-12 was located adjacent to previous hole AP-99-3 which had been drilled to a depth of 45.7 feet earlier in the study (this is the deepest hole we drilled at Savage Rapids). I anticipated similar depths for AP-99-12 and decided to alternate between heavy metals and standard properties testing in that hole with samples spaced about 3 to 4 feet apart. We obtained an excellent sample from the surface of the lakebed (26.9-28.9') and also collected an additional heavy metals sample from 35.7-37.7'. I had anticipated that we would be able to collect one more heavy metals sample at about 45 feet, but the hole attained refusal after a standard properties sample was collected from 41.1-43.1'. Although the barrel had not been decontaminated prior to that last sample interval, I decided to go ahead and split it and send part in for heavy metals testing as this sample was located in a critical location immediately above the pre-dam river channel. **This last interval (41.1-43.1') is the only sample sent to you that did not go through the decontamination process.**

I hope this helps alert you to the irregularities we experienced in the testing. The bulk of the samples consist of sand particles. The sample from 35.7-37.7' was taken from a layer of silty sand at the top of the interval and contains the highest fines concentration in any of the samples we obtained at Savage Rapids (my field estimate is about 35% nonplastic fines).

Give me a call if you have any further questions or comments.

Dick